

SIEMENS



Overcurrent Protection 7SJ80 SIPROTEC Compact

Overcurrent Protection SIPROTEC 7SJ80

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You will find a detailed overview of the technical data (extract of the manual) under:
<http://www.siemens.com/siprotec>

Description

The SIPROTEC 7SJ80 relays can be used for line/feeder protection of high and medium-voltage networks with grounded, low-resistance grounded, isolated or a compensated neutral point. The relays have all the required functions to be applied as a backup relay to a transformer differential relay.

The SIPROTEC 7SJ80 features “flexible protection functions”. Up to 20 additional protection functions can be created by the user.

Therefore protection of change for frequency or reverse power protection can be realized, for example.

The relay provides circuit-breaker control, further switching devices and automation functions. The integrated programmable logic (CFC) allows the user to add own functions, e.g. for the automation of switchgear (interlocking). The user is also allowed to generate user-defined messages.

Highlights

- Pluggable current and voltage terminals
- Binary input thresholds settable using DIGSI (3 stages)
- Secondary current transformer values (1 A/5 A) settable using DIGSI
- 9 programmable function keys
- 6-line display
- Buffer battery exchangeable from the front
- USB front port
- 2 additional communication ports
- Integrated switch for low-cost and redundant optical Ethernet rings
- Ethernet redundancy protocols RSTP, PRP and HSR for highest availability
- Relay-to-relay communication through Ethernet with IEC 61850 GOOSE
- Millisecond-accurate time synchronization through Ethernet with SNTP (over Port A or Port B)
- Number of binary inputs and binary outputs by connection from up to two SICAM I/O-Units extendable.



Fig. 4/1 SIPROTEC 7SJ80 front view, housing



Fig. 4/2 SIPROTEC 7SJ80 rear view

Overcurrent Protection SIPROTEC 7SJ80

Function overview

Protection functions	IEC	ANSI No.
Definite and inverse time-overcurrent protection (phase/ground)	$I>, I_p, I_{Np}$	50, 50N; 51, 51N
Directional time-overcurrent protection phase	$I>, I>>, I>>>, I_p$	67
Directional time-overcurrent protection ground	$I_E>, I_E>>, I_E>>>, I_{Ep}$	67N ¹⁾
Directional sensitive ground fault protection	$I_{EE}>, I_{EE}>>, I_{EEp}$	67Ns ¹⁾ , 50Ns
Overvoltage protection, zero-sequence system	$V_E, V_{0>}$	59N ¹⁾
High-impedance restricted ground-fault protection		87N
Inrush restraint		
Trip-circuit supervision	TCS	74TC
Undercurrent monitoring	$I<, P>$	37
Overload protection	$\vartheta>$	49
Undervoltage/overvoltage protection	$V<, V>$	27/59
Overfrequency/underfrequency protection	$f<, f>$	81O/U
Circuit-breaker failure protection	CBFP	50BF
Undervoltage controlled reactive power protection	$Q>/V<$	
Intermittent ground fault protection	lie>	
Directional intermittent ground fault protection	lie dir>	67Ns ¹⁾
Voltage dependent inverse-time overcurrent protection		51V
Unbalanced-load protection	$I_2>$	46
Phase-sequence-voltage supervision	LA, LB, LC	47
Synchrocheck	Sync	25
Automatic reclosing	AR	79
Fault locator	FL	FL ¹⁾
Lockout		86
Forward power supervision, reverse power protection	$P<>, Q<>$	32 ¹⁾
Power factor	$\cos \varphi$	55 ¹⁾
Rate-of-frequency-change protection	df/dt	81R
Rate-of-voltage-change protection	dV/dt	27R, 59R

Table 4/1 Function overview

Control functions/programmable logic

- Commands for the ctrl. of CB, disconnect switches (isolators/isolating switches)
- Control through keyboard, binary inputs, DIGSI 4 or SCADA system
- User-defined PLC logic with CFC (e.g. interlocking).

Monitoring functions

- Operational measured values V, I, f
- Energy metering values W_p, W_q
- Circuit-breaker wear monitoring
- Minimum and maximum values
- Trip circuit supervision (74TC)
- Fuse failure monitor
- 8 oscillographic fault records.

1) Not available if function package "Q" (synchrocheck, ANSI 25) is selected.

Communication interfaces

- System/service interface
 - IEC 61850 Edition 1 and 2
 - IEC 60870-5-103 and IEC 60870-5-104
 - PROFIBUS-DP
 - DNP 3.0
 - MODBUS RTU
 - DNP3 TCP
 - PROFINET
 - Ethernet redundancy protocols RSTP, PRP and HSR
- Ethernet interface for DIGSI 4 and extension up to two SICAM I/O-Units 7XV5673
- USB front interface for DIGSI 4.

Hardware

- 4 current transformers
- 0/3 voltage transformers
- 3/7/11 binary inputs (thresholds configurable using software)
- 5/8 binary outputs (2 changeover/Form C contacts)
- 1 life contact
- Pluggable current and voltage terminals.

The SIPROTEC 7SJ80 perform control and monitoring functions and therefore provide the user with a cost-effective platform for power system management, that ensures reliable supply of electrical power to the customers. The ergonomic design makes control easy from the relay front panel. A large, easy-to-read display was a key design factor.

Control

The integrated control function permits control of disconnect devices, grounding switches or circuit-breakers through the integrated operator panel, binary inputs, DIGSI 4 or the control or automation system (e.g. SICAM)

Programmable logic

The integrated logic characteristics (CFC) allow the user to add own functions for automation of switchgear (e.g. interlocking) or switching sequence. The user can also generate user-defined messages. This functionality can form the base to create extremely flexible transfer schemes.

Operational measured value

Extensive measured values (e.g. I , V), metered values (e.g. W_p , W_q) and limit values (e.g. for voltage, frequency) provide improved system management.

Operational indication

Event logs, trip logs, fault records and statistics documents are stored in the relay to provide the user or operator with all the key data required to operate modern substations.

Line protection

The SIPROTEC 7SJ80 units can be used for line protection of high and medium-voltage networks with grounded, low-resistance grounded, isolated or a compensated neutral point.

Transformer protection

The relay provides all the functions for backup protection for transformer differential protection. The inrush suppression effectively prevents unwanted trips that can be caused by inrush currents. The high-impedance restricted ground-fault protection detects short-circuits and insulation faults on the transformer.

Backup protection

As a backup protection the SIPROTEC 7SJ80 devices are universally applicable.

Switchgear cubicles for high/medium voltage

All units are designed specifically to meet the requirements of high/medium-voltage applications. In general, no separate measuring instruments (e.g., for current, voltage, frequency, ...) or additional control components are necessary.

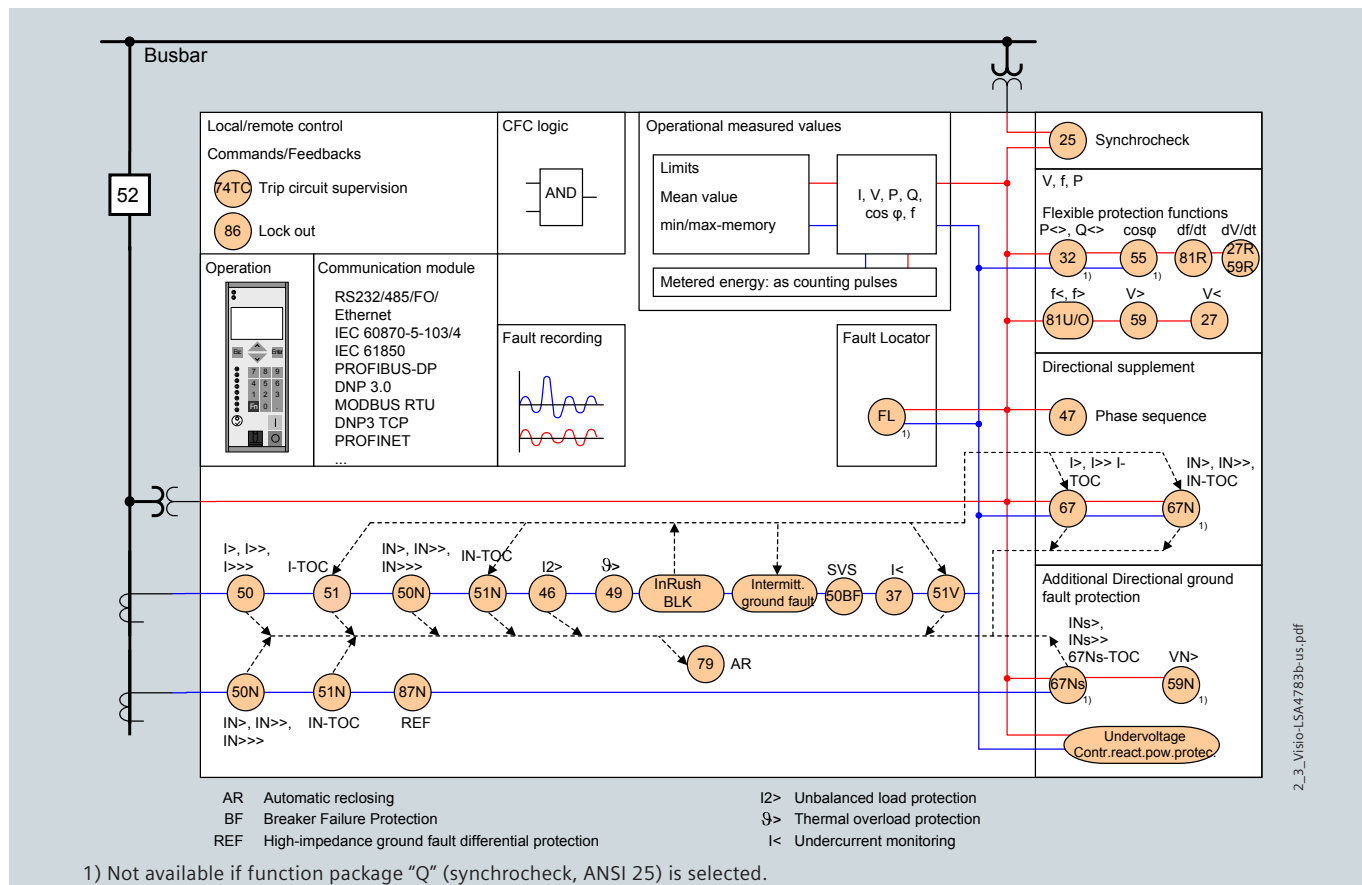


Fig. 4/3 Function diagram

Overcurrent Protection SIPROTEC 7SJ80

Application sheets

Protection functions

Overcurrent protection (ANSI 50, 50N, 51, 51N, 51V)

This function is based on the phase selective measurement of the three phase currents and the ground current (four transformers). Three definite time-overcurrent protection elements (DMT) are available both for the phase and the ground elements. The current threshold and the delay time can be set in a wide range.

Inverse time-overcurrent protection characteristics (IDMTL) can also be selected and activated. The inverse-time function provides – as an option – voltage-restraint or voltage-controlled operating modes

Reset characteristics

Time coordination with electromechanical relays are made easy with the inclusion of the reset characteristics according to ANSI C37.112 and IEC 60255-3/BS 142 standards. When using the reset characteristic (disk emulation), the reset process is initiated after the fault current has disappeared. This reset process corresponds to the reverse movement of the Ferraris disk of an electromechanical relay (disk emulation).

Available inverse-time characteristics

Characteristics acc. to	IEC 60255-3	ANSI/IEEE
Inverse	•	•
Short inverse		•
Long inverse	•	•
Moderately inverse		•
Very inverse	•	•
Extremely inverse	•	•

Table 4/2 Available inverse-time characteristics

Inrush restraint

If second harmonic content is detected during the energization of a transformer, the pickup of stages $I>$, I_{p} , $I>_{dir}$ and $I_{p\ dir}$ is blocked.

Dynamic settings group switching

In addition to the static parameter changeover, the pickup thresholds and the tripping times for the directional and non-directional time-overcurrent protection functions can be changed over dynamically. As changeover criterion, the circuit-breaker position, the prepared auto-reclosure, or a binary input can be selected.

Directional comparison protection (cross-coupling)

It is used for selective instantaneous tripping of sections fed from two sources, i.e. without the disadvantage of time delays of the set characteristic. The directional comparison protection is suitable if the distances between the protection zones are not significant and pilot wires are available for signal transmission. In addition to the directional comparison protection, the directional coordinated time-overcurrent protection is used for complete selective backup protection.

Directional time-overcurrent protection (ANSI 67, 67N)

Directional phase and ground protection are separate functions. They operate in parallel to the non-directional overcurrent elements. Their pickup values and delay times can be set separately. Definite-time and inverse-time characteristics are offered. The tripping characteristic can be rotated by ± 180 degrees.

By making use of the voltage memory, the directionality can be determined reliably even for close-in (local) faults. If the primary switching device closes onto a fault and the voltage is too low to determine direction, the direction is determined using voltage from the memorized voltage. If no voltages are stored in the memory, tripping will be according to the set characteristic.

For ground protection, users can choose whether the direction is to be calculated using the zero-sequence or negative-sequence system quantities (selectable). If the zero-sequence voltage tends to be very low due to the zero-sequence impedance it will be better to use the negative-sequence quantities.

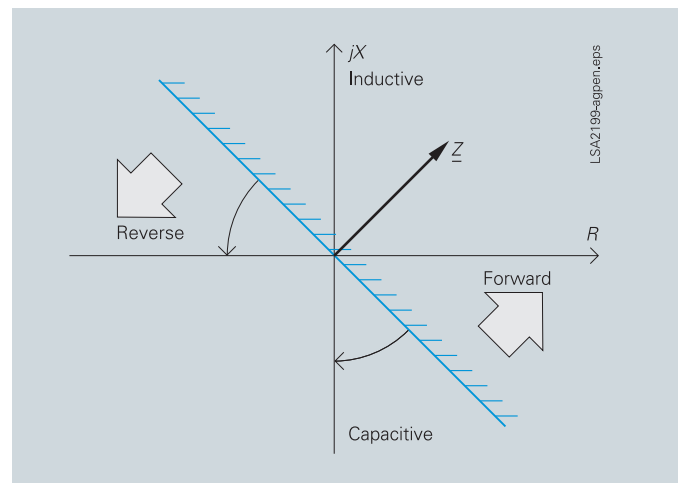


Fig. 4/4 Directional characteristics of the directional time-overcurrent protection

(Sensitive) directional ground-fault detection (ANSI 59N/64, 67Ns, 67N)

For isolated-neutral and compensated networks, the direction of power flow in the zero sequence is calculated from the zero-sequence current I_0 and zero-sequence voltage V_0 . For networks with an isolated neutral, the reactive current component is evaluated; for compensated networks, the active current component or residual resistive current is evaluated. For special network conditions, e.g. high-resistance grounded networks with ohmic-capacitive ground-fault current or low-resistance grounded networks with ohmic-inductive current, the tripping characteristics can be rotated approximately ± 45 degrees (see Fig.4/5).

Two modes of ground-fault direction detection can be implemented: tripping or "signalling only mode".

(Sensitive) directional ground-fault detection (ANSI 59N, 67Ns, 67N) (contin.)

It has the following functions:

- TRIP via the displacement voltage V_E
- Two instantaneous elements or one instantaneous plus one user-defined characteristic
- Each element can be set to forward, reverse or non-directional
- The function can also be operated in the insensitive mode as an additional short-circuit protection.

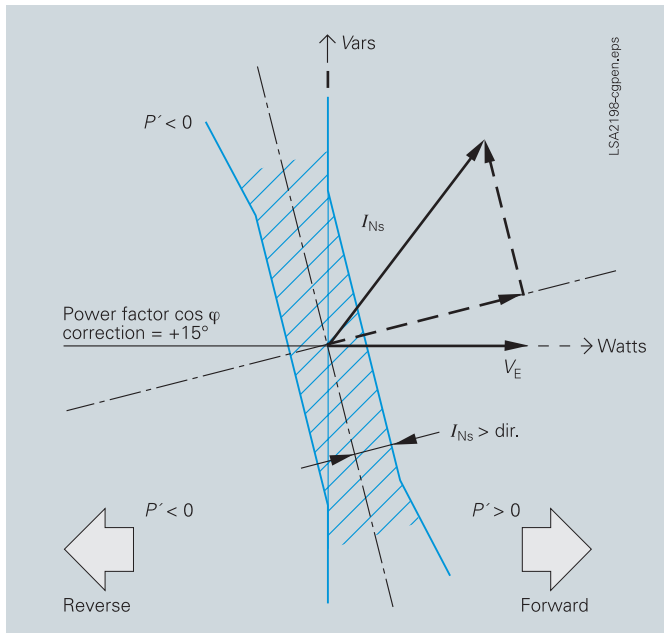


Fig. 4/5 Directional determination using cosine measurements for compensated networks

(Sensitive) ground-fault detection (ANSI 50Ns, 51Ns / 50N, 51N)

For high-resistance grounded networks, a sensitive input transformer is connected to a phase-balance neutral current transformer (also called core-balance CT). The function can also be operated in the normal mode as an additional short-circuit protection for neutral or residual ground protection.

Intermittent ground fault protection

Intermittent (re-igniting) faults are caused by poor cable insulation or water ingress into cable joints. After some time, the faults extinguish automatically or they develop into permanent short circuits. During the intermitting, neutral point resistances in impedance grounded systems can suffer thermal overload.

The normal ground fault protection is not capable of reliably detecting and clearing the sometimes very short current pulses. The required selectivity for intermittent ground faults is achieved by summing up the times of the individual pulses and tripping after a (programmable) summation time has been reached. The pickup threshold $I_{E>}$ evaluates RMS values referred to 1 system period.

Negative-sequence system overcurrent protection (ANSI 46)

By measuring current on the high side of the transformer, the two-element phase-balance current/negative-sequence protection detects high-resistance phase-to-phase faults and phase-to-ground faults on the low side of a transformer (e.g. Dy 5). This function provides backup protection for high-resistance faults through the transformer.

Directional intermittent ground fault protection (ANSI 67Ns)

The directional intermittent ground fault protection has to detect intermittent ground faults in resonant grounded cable systems selectively. Intermittent ground faults in resonant grounded cable systems are usually characterized by the following properties:

- A very short high-current ground current pulse (up to several hundred amperes) with a duration of under 1 ms
- They are self-extinguishing and re-ignite within one half-period up to several periods, depending on the power system conditions and the fault characteristic.
- Over longer periods (many seconds to minutes), they can develop into static faults.

Such intermittent ground faults are frequently caused by weak insulation, e.g. due to decreased water resistance of old cables.

Ground fault functions based on fundamental component measured values are primarily designed to detect static ground faults and do not always behave correctly in case of intermittent ground faults. The function described here evaluates specifically the ground current pulses and puts them into relation with the zero-sequence voltage to determine the direction.

Undervoltage-controlled reactive power protection

The undervoltage-controlled reactive power protection protects the system for mains decoupling purposes. To prevent a voltage collapse in energy systems, the generating side, e.g. a generator, must be equipped with voltage and frequency protection devices. An undervoltage-controlled reactive power protection is required at the supply system connection point. It detects critical power system situations and ensures that the power generation facility is disconnected from the mains. Furthermore, it ensures that reconnection only takes place under stable power system conditions. The associated criteria can be parameterized.

Breaker failure protection (ANSI 50BF)

If a faulted portion of the electrical circuit is not disconnected when a trip command is issued to a circuit-breaker, another trip command can be initiated using the breaker failure protection which trips the circuit-breaker of an upstream feeder. Breaker failure is detected if, after a trip command is issued and the current keeps on flowing into the faulted circuit. It is also possible to make use of the circuit-breaker position contacts for indication as opposed to the current flowing through the circuit-breaker.

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Application sheets

High-impedance restricted ground-fault protection (ANSI 87N)

The high-impedance measurement principle is a simple and sensitive method to detect ground faults, especially on transformers. It can also be used on motors, generators and reactors when they are operated on a grounded network. When applying the high-impedance measurement principle, all current transformers in the protected area are connected in parallel and operated through one common resistor of relatively high R . The voltage is measured across this resistor (see Fig. 4/6).

The voltage is measured by detecting the current through the (external) resistor R at the sensitive current measurement input I_{EE} . The varistor V serves to limit the voltage in the event of an internal fault.

It limits the high instantaneous voltage spikes that can occur at current transformer saturation. At the same time, this results to smooth the voltage without any noteworthy reduction of the average value.

If no faults have occurred and in the event of external or through faults, the system is at equilibrium, and the voltage through the resistor is approximately zero. In the event of internal faults, an imbalance occurs which leads to a voltage and a current flowing through the resistor R .

The same type of current transformers must be used and must at least offer a separate core for the high-impedance restricted ground-fault protection. They must have the same transformation ratio and approximately an identical knee-point voltage. They should also have only minimal measuring errors.

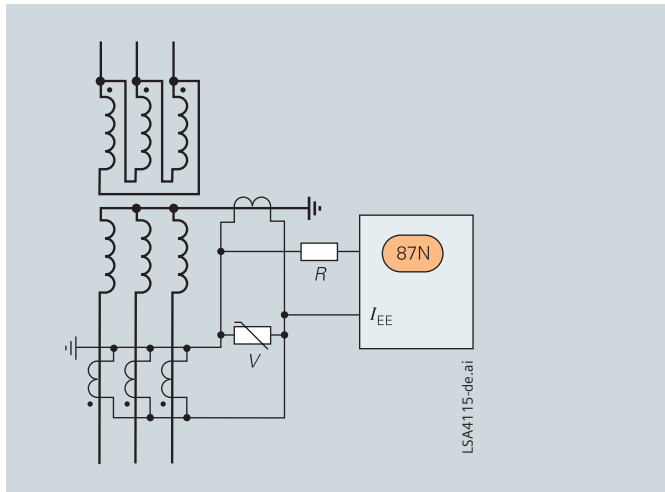


Fig. 4/6 High-impedance restricted ground-fault protection

Automatic reclosing (ANSI 79)

Multiple re-close cycles can be set by the user and lockout will occur if a fault is present after the last re-close cycle. The following functions are available:

- 3-pole ARC for all types of faults
- Separate settings for phase and ground faults
- Multiple ARC, one rapid auto-reclosure (RAR) and up to nine delayed auto-reclosures (DAR)

- Initiation of the ARC is dependant on the trip command selected (e.g. $I_{2>}$, $I_{>>}$, I_p , $I_{dir>}$)
- The ARC function can be blocked by activating a binary input
- The ARC can be initiated from external or by the PLC logic (CFC)
- The directional and non-directional elements can either be blocked or operated non-delayed depending on the auto-reclosure cycle
- If the ARC is not ready it is possible to perform a dynamic setting change of the directional and non-directional overcurrent elements.

Flexible protection functions

The SIPROTEC 7SJ80 enables the user to easily add up to 20 additional protection functions. Parameter definitions are used to link standard protection logic with any chosen characteristic quantity (measured or calculated quantity). The standard logic consists of the usual protection elements such as the pickup set point, the set delay time, the TRIP command, a block function, etc. The mode of operation for current, voltage, power and power factor quantities can be three-phase or single-phase. Almost all quantities can be operated with ascending or descending pickup stages (e.g. under and overvoltage). All stages operate with protection priority.

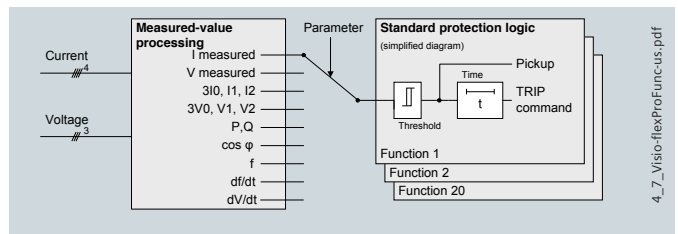


Fig. 4/7 Flexible protection functions

Protection functions/stages available are based on the available measured analog quantities:

Function	ANSI
$I_{>}$, $I_{E>}$	50, 50N
$V_{<}$, $V_{>}$, $V_{E>}$	27, 59, 59N
$3I_{0>}$, $I_{1>}$, $I_{2>}$, $I_{2/I1>}$, $3V_{0>}$, $V_{1> <}$, $V_{2 <}$	50N, 46, 59N, 47
$P_{> <}$, $Q_{> <}$	32
$\cos \varphi$	55
$f > <$	81O, 81U
$df/dt > <$	81R
dV/dt	27R/59R

Table 4/3 Available flexible protection functions

For example, the following can be implemented:

- Reverse power protection (ANSI 32R)
- Rate-of-frequency-change protection (ANSI 81R)
- Rate-of-voltage-change protection (ANSI 27R/59R).

Synchrocheck, synchronizing function (ANSI 25)

When closing a circuit-breaker, the units can check whether two separate networks are synchronized. Voltage-, frequency- and phase-angle-differences are checked to determine whether synchronous conditions exist.

Trip circuit supervision (ANSI 74TC)

One or two binary inputs can be used for monitoring the circuit-breaker trip coil including its incoming cables. An alarm signal is generated whenever the circuit is interrupted.

Lockout (ANSI 86)

All binary output statuses can be memorized. The LED reset key is used to reset the lockout state. The lockout state is also stored in the event of supply voltage failure. Reclosure can only occur after the lockout state is reset.

Thermal overload protection (ANSI 49)

To protect cables and transformers, an overload protection function with an integrated warning/alarm element for temperature and current can be used. The temperature is calculated using a thermal homogeneous body model (per IEC 60255-8), it considers the energy entering the equipment and the energy losses. The calculated temperature is constantly adjusted according to the calculated losses. The function considers loading history and fluctuations in load.

Settable dropout delay times

If the relays are used in conjunction with electromechanical relays, in networks with intermittent faults, the long dropout times of the electromechanical relay (several hundred milliseconds) can lead to problems in terms of time coordination/grading. Proper time coordination/grading is only possible if the dropout or reset time is approximately the same. This is why the parameter for dropout or reset times can be defined for certain functions, such as overcurrent protection, ground short-circuit and phase-balance current protection.

Undercurrent monitoring (ANSI 37)

A sudden drop in current, which can occur due to a reduced load, is detected with this function. This may be due to shaft that breaks, no-load operation of pumps or fan failure.

Overvoltage protection (ANSI 59)

The two-element overvoltage protection detects unwanted network and machine overvoltage conditions. The function can operate either with phase-to-phase, phase-to-ground, positive phase-sequence or negative phase-sequence voltage. Three-phase and single-phase connections are possible.

Undervoltage protection (ANSI 27)

The two-element undervoltage protection provides protection against dangerous voltage drops (especially for electric machines). Applications include the isolation of generators or motors from the network to avoid undesired operating conditions and a possible loss of stability. Proper operating conditions of electrical machines are best evaluated with the positive-sequence quantities. The protection function is active over a wide frequency range (45 to 55, 55 to 65 Hz). Even when falling below this frequency range the function continues to work, however, with decrease accuracy. The function can operate either with phase-to-phase, phase-to-ground or positive phase-sequence voltage, and can be monitored with a current criterion. Three-phase and single-phase connections are possible.

Frequency protection (ANSI 81O/U)

Frequency protection can be used for overfrequency and underfrequency protection. Electric machines and parts of the system are protected from unwanted frequency deviations. Unwanted frequency changes in the network can be detected and the load can be removed at a specified frequency setting. Frequency protection can be used over a wide frequency range (40 to 60 (for 50 Hz), 50 to 70 (for 60 Hz)). There are four elements (individually set as overfrequency, underfrequency or OFF) and each element can be delayed separately. Blocking of the frequency protection can be performed by activating a binary input or by using an undervoltage element.

Fault locator (ANSI 21FL)

The integrated fault locator calculates the fault impedance and the distance to fault. The results are displayed in Ω , kilometers (miles) and in percent of the line length.

Customized functions (ANSI 51V, 55 etc.)

Additional functions, which are not time critical, can be implemented using the CFC measured values. Typical functions include reverse power, voltage controlled overcurrent, phase angle detection, and zero-sequence voltage detection.

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Application sheets

Further functions

Measured values

The r.m.s. values are calculated from the acquired current and voltage along with the power factor, frequency, active and reactive power. The following functions are available for measured value processing:

- Currents I_{L1} , I_{L2} , I_{L3} , I_N , I_{EE}
- Voltages V_{L1} , V_{L2} , V_{L3} , V_{12} , V_{23} , V_{31}
- Symmetrical components I_1 , I_2 , $3I_0$; V_1 , V_2 , $3V_0$
- Power Watts, Vars, VA/P, Q, S (P, Q: total and phase selective)
- Power factor $\cos \varphi$ (total and phase selective)
- Frequency
- Energy \pm kWh, \pm kVarh, forward and reverse power flow
- Mean as well as minimum and maximum current and voltage values
- Operating hours counter
- Mean operating temperature of the overload function
- Limit value monitoring
Limit values can be monitored using programmable logic in the CFC. Commands can be derived from this limit value indication.
- Zero suppression
In a certain range of very low measured values, the value is set to zero to suppress interference.

Metered values

For internal metering, the unit can calculate an energy metered value from the measured current and voltage values. If an external meter with a metering pulse output is available, the SIPROTEC 7SJ80 can obtain and process metering pulses through an indication input. The metered values can be displayed and passed on to a control center as an accumulated value with reset. A distinction is made between forward, reverse, active and reactive energy.

Binary I/O extension with SICAM I/O-Unit 7XV5673

To extend binary inputs and binary outputs for SIPROTEC 7SJ80 up to two SICAM I/O-Units 7XV5673 can be added. Each SICAM I/O-Unit 7XV5673 is equipped with 6 binary inputs and 6 binary outputs and an Ethernet switch for cascading. The connection to the protection device can be either through the DIGSI Ethernet service interface Port A or through IEC 61850 GOOSE on Port B (System interface with EN100 module).

Circuit-breaker wear monitoring/ circuit-breaker remaining service life

Methods for determining circuit-breaker contact wear or the remaining service life of a circuit-breaker (CB) allow CB maintenance intervals to be aligned to their actual degree of wear. The benefit lies in reduced maintenance costs.

There is no exact mathematical method to calculate the wear or the remaining service life of a circuit-breaker that takes arc-chamber's physical conditions into account when the CB opens.

This is why various methods of determining CB wear have evolved which reflect the different operator philosophies. To do justice to these, the relay offers several methods:

- ΣI
- ΣI^x , with $x = 1..3$
- $\Sigma i^2 t$.

The devices also offer a new method for determining the remaining service life:

- Two-point method

The CB manufacturers double-logarithmic switching cycle diagram (see Fig. 4/8) and the breaking current at the time of contact opening serve as the basis for this method. After CB opening, the two-point method calculates the remaining number of possible switching cycles. Two points P1 and P2 only have to be set on the device. These are specified in the CB's technical data.

All of these methods are phase-selective and a limit value can be set in order to obtain an alarm if the actual value falls below or exceeds the limit value during determination of the remaining service life.

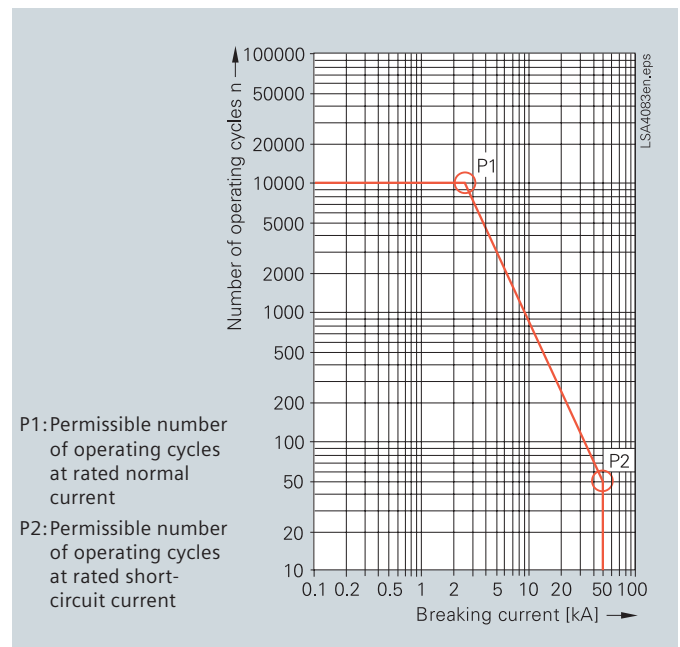


Fig. 4/8 Permissible number of operating cycles as a function of breaking current

Commissioning

Commissioning could not be easier and is supported by DIGSI 4. The status of the binary inputs can be read individually and the state of the binary outputs can be set individually. The operation of switching elements (circuit-breakers, disconnect devices) can be checked using the switching functions of the relay. The analog measured values are represented as wide-ranging operational measured values. To prevent transmission of information to the control center during maintenance, the communications can be disabled to prevent unnecessary data from being transmitted. During commissioning, all indications with test tag for test purposes can be connected to a control and protection system.

Test operation

During commissioning, all indications with test tag can be passed to a control system for test purposes.

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Application examples

Radial systems

General hints:

The relay at the far end (D) from the infeed has the shortest tripping time. Relays further upstream have to be time-graded against downstream relays in steps of about 0.3 s.

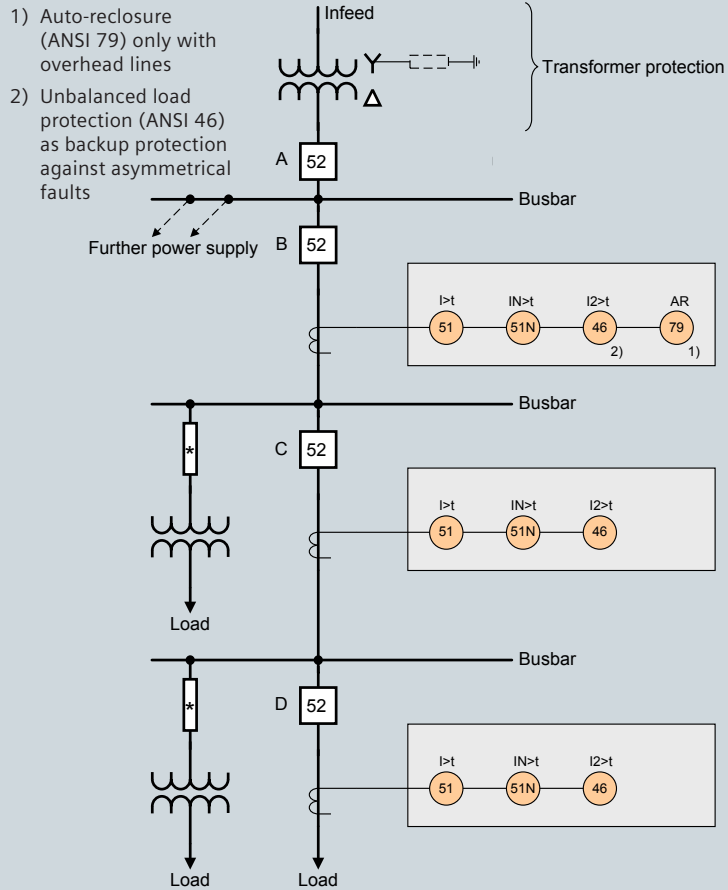


Fig. 4/9 Protection concept with time-overcurrent protection

Earth-fault detection in isolated or compensated systems

In isolated or compensated systems, an occurred earth fault can be easily found by means of sensitive directional earth-fault detection.

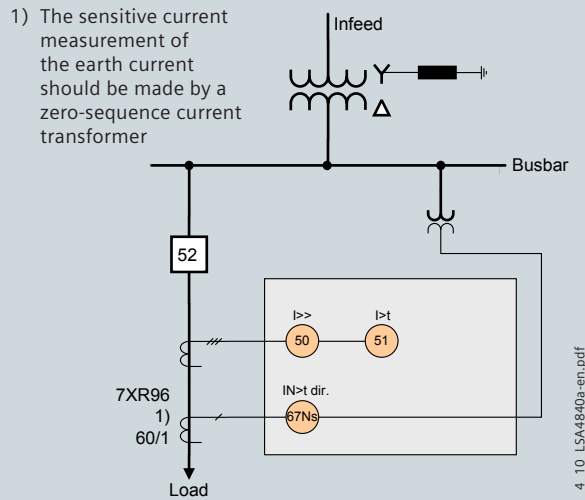


Fig. 4/10 Protection concept for directional earth-fault detection

Ring-main cable

With the directional comparison protection, 100% of the line can be protected via instantaneous tripping in case of infeed from two sources (ring-main cable).

For lines with infeed from two sources, no selectivity can be achieved with a simple definite-time overcurrent protection. Therefore, the directional definite-time overcurrent protection must be used. A non-directional definite-time overcurrent protection is enough only in the corresponding busbar feeders. The grading is done from the other end respectively.

Advantage: 100% protection of the line via instantaneous tripping, and easy setting.

Disadvantage: Tripping times increase towards the infeed.

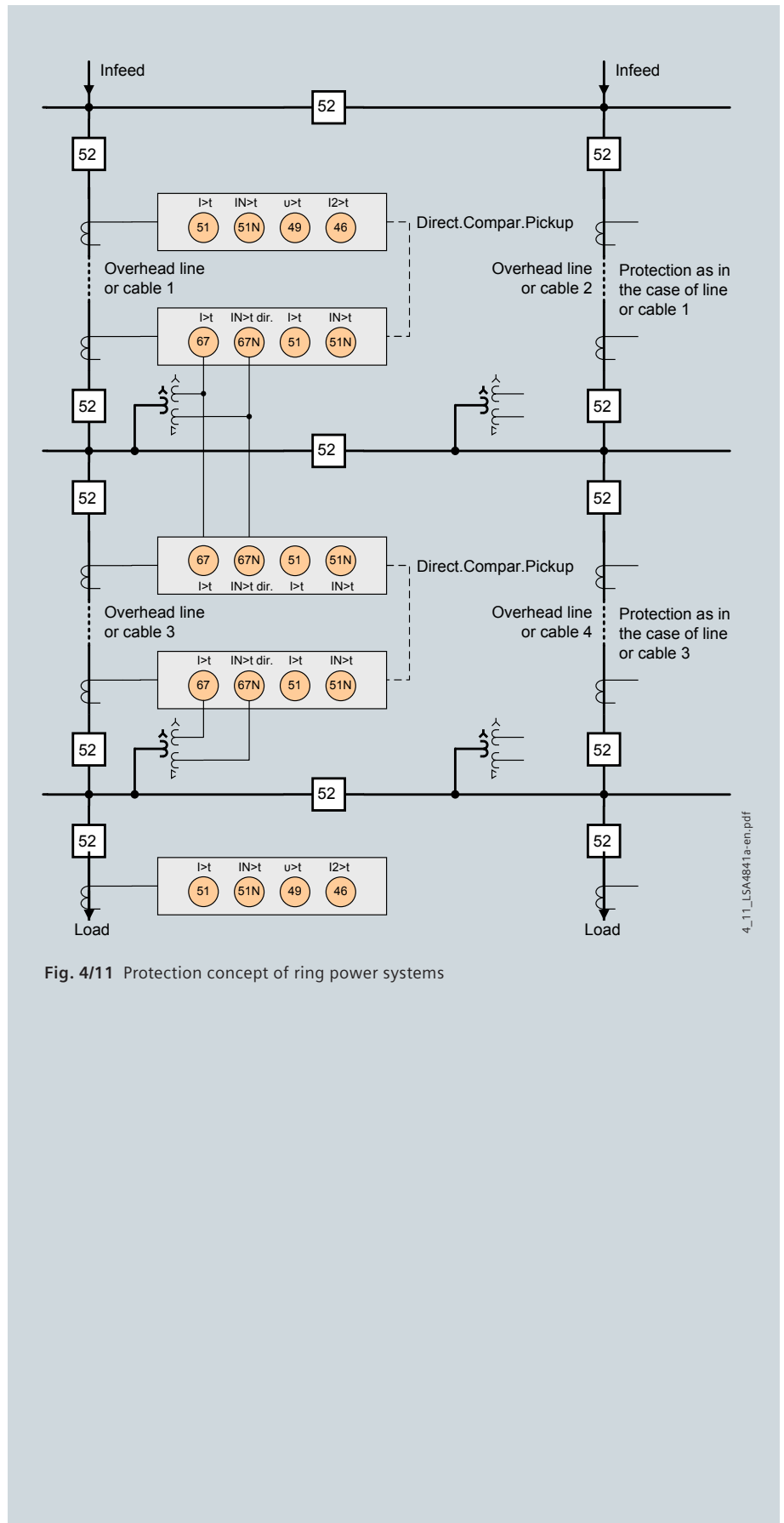


Fig. 4/11 Protection concept of ring power systems

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Overcurrent Protection SIPROTEC 7SJ80

Application examples

Busbar protection by overcurrent relays with reverse interlocking

Applicable to distribution busbars without substantial ($< 0.25 \times I_N$) backfeed from the outgoing feeders.

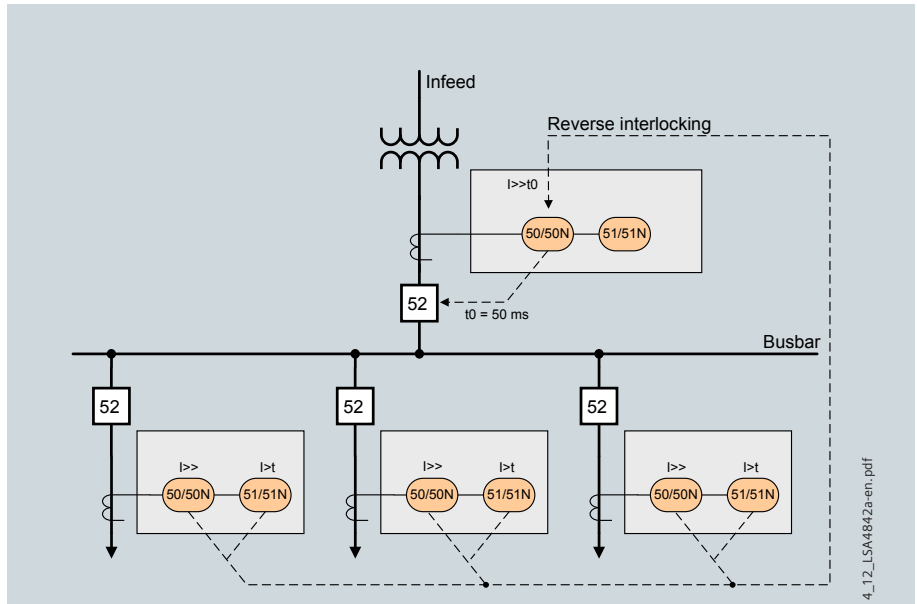


Fig. 4/12 Busbar protection via overcurrent relays with reverse interlocking

Line feeder with load shedding

In unstable power systems (e.g. solitary systems, emergency power supply in hospitals), it may be necessary to isolate selected consumers from the power system in order to protect the overall system. The overcurrent-time protection functions are effective only in the case of a short-circuit. Overloading of the generator can be measured as a frequency or voltage drop.

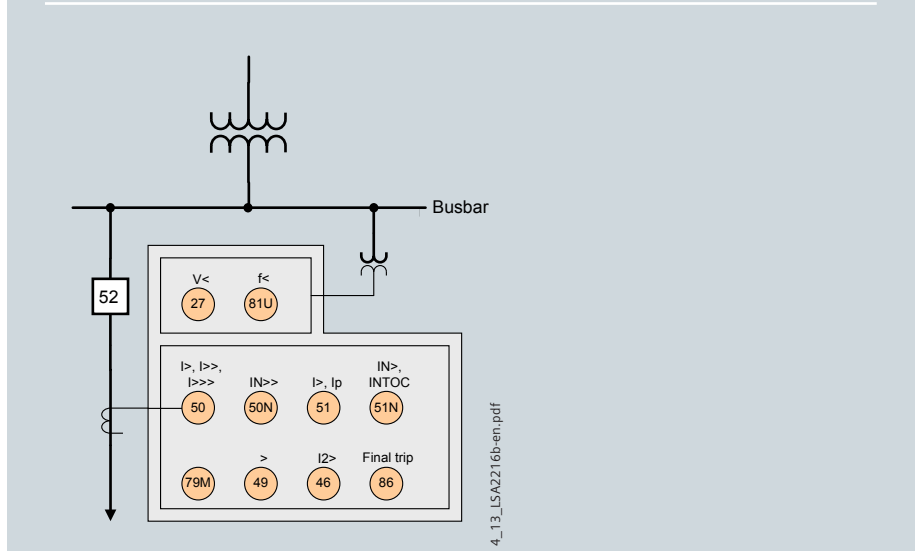


Fig. 4/13 Line feeder with load shedding

Automatic reclosing

The Automatic reclosing function (AR) has starting and blocking options. In the opposite example, the application of the blocking of the high-current stages is represented according to the reclosing cycles. The overcurrent protection is graded (stages I , I_p) according to the grading plan. If an Automatic reclosing function is installed in the incoming supply of a feeder, first of all the complete feeder is tripped instantaneously in case of fault. Arc faults will be extinguished independently of the fault location. Other protection relays or fuses do not trip (fuse saving scheme). After successful Automatic reclosing, all consumers are supplied with energy again. If there is a permanent fault, further reclosing cycles will be performed. Depending on the setting of the AR, the instantaneous tripping stage in the infeed is blocked in the first, second or third cycle, i.e., now the grading is effective according to the grading plan. Depending on the fault location, overcurrent relays with faster grading, fuses, or the relay in the infeed will trip. Only the part of the feeder with the permanent fault will be shut down definitively.

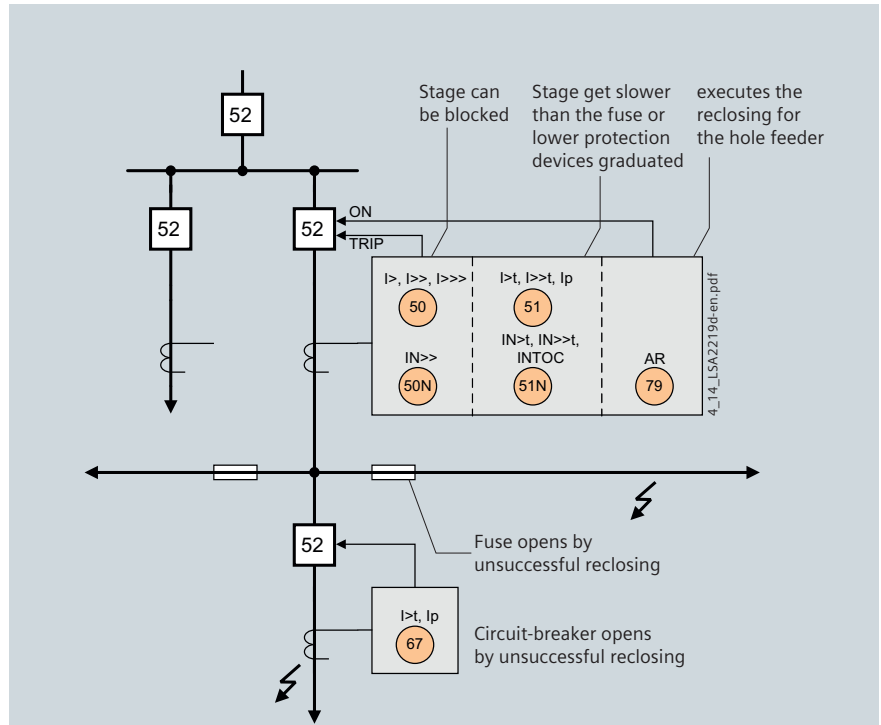


Fig. 4/14 Auto-reclosure

Reverse power protection with parallel infeeds

If a busbar is supplied by two parallel infeeds and there is a fault in one of the infeeds, the affected busbar shall be selectively shut down, so that supply to the busbar is still possible through the remaining infeed. To do this, directional devices are required, which detect a short circuit from the busbar towards the infeed. In this context, the directional time-overcurrent protection is normally adjusted over the load current. Low-current faults cannot be shut down by this protection. The reverse power protection can be adjusted far below rated power, and is thus also able to detect reverse power in case of low-current faults far below the load current. The reverse power protection is implemented through the "flexible protection functions".

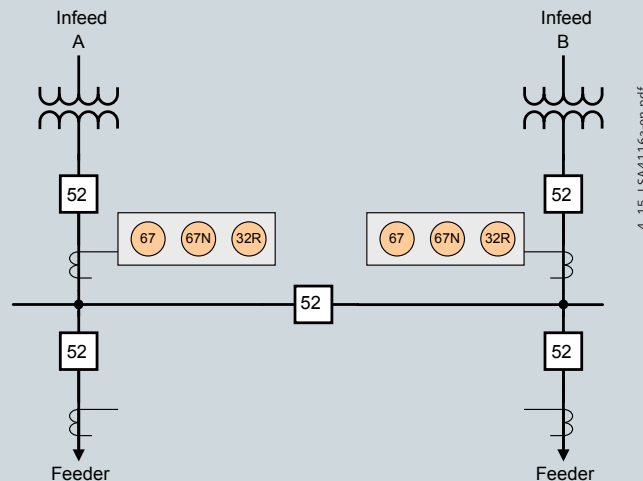


Fig. 4/15 Reverse power protection with parallel infeeds

Overcurrent Protection SIPROTEC 7SJ80

Application examples

Synchrocheck

Where two system sections are interconnected, the synchrocheck determines whether the connection is permissible without danger to the stability of the power system. In the example, load is supplied from a generator to a busbar through a transformer. The vector group of the transformer can be considered by means of a programmable angle adjustment, so that no external adjustment elements are necessary. Synchrocheck can be used for auto-reclosure, as well as for control functions (local or remote).

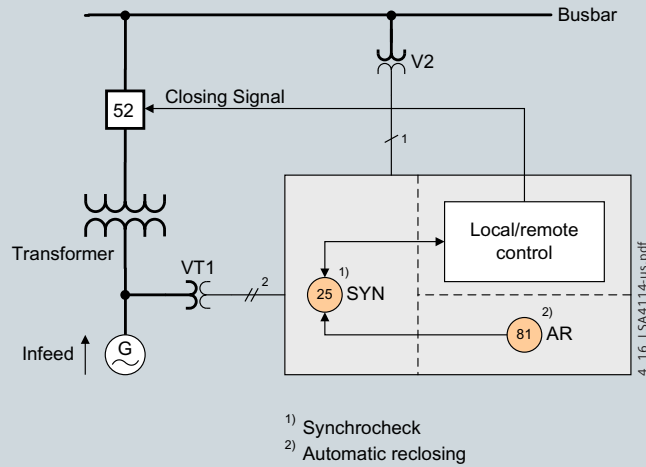


Fig. 4/16 Measurement of busbar and feeder voltage for synchronization

Protection of a transformer

The high-current stage enables a current grading, the overcurrent stages work as backup protection to subordinate protection devices, and the overload function protects the transformer from thermal overload. Low-current, single-phase faults on the low-voltage side, which are reproduced in the opposite system on the high-voltage side, can be detected with the unbalanced load protection. The available inrush blocking prevents pickup caused by the inrush currents of the transformer.

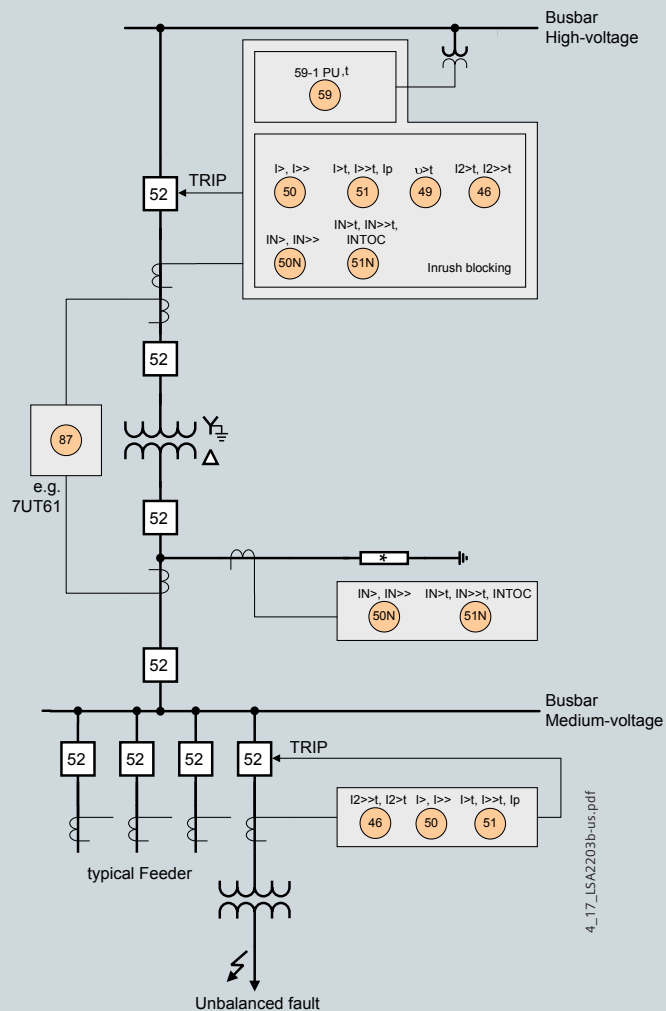


Fig. 4/17 Typical protection concept for a transformer

Undervoltage-controlled reactive power protection (QV Protection)

When connecting generating units to the medium-voltage power system of the operator, a protective disconnection device is required which takes into account frequency and voltage and also evaluates the reactive power direction. When the generating unit draws reactive power from the operator's power system, Undervoltage-controlled reactive power protection (Q> & V<) links the reactive power with all three phase-to-phase voltages falling below a limiting value using a logical AND operation.

This ensures that generating units disconnect from the power system which additionally burden the power system during a short circuit or prevent that the power system is re-stored when connecting after a short circuit. The monitoring of the voltage support also fulfills this function.

Using the criteria mentioned above the QV protection disconnects the generating unit from the power system after a programmable time.

The QV protection furthermore allows releasing the re-connection after the fault has been located and cleared in the power system and the system voltage and frequency are stable again.

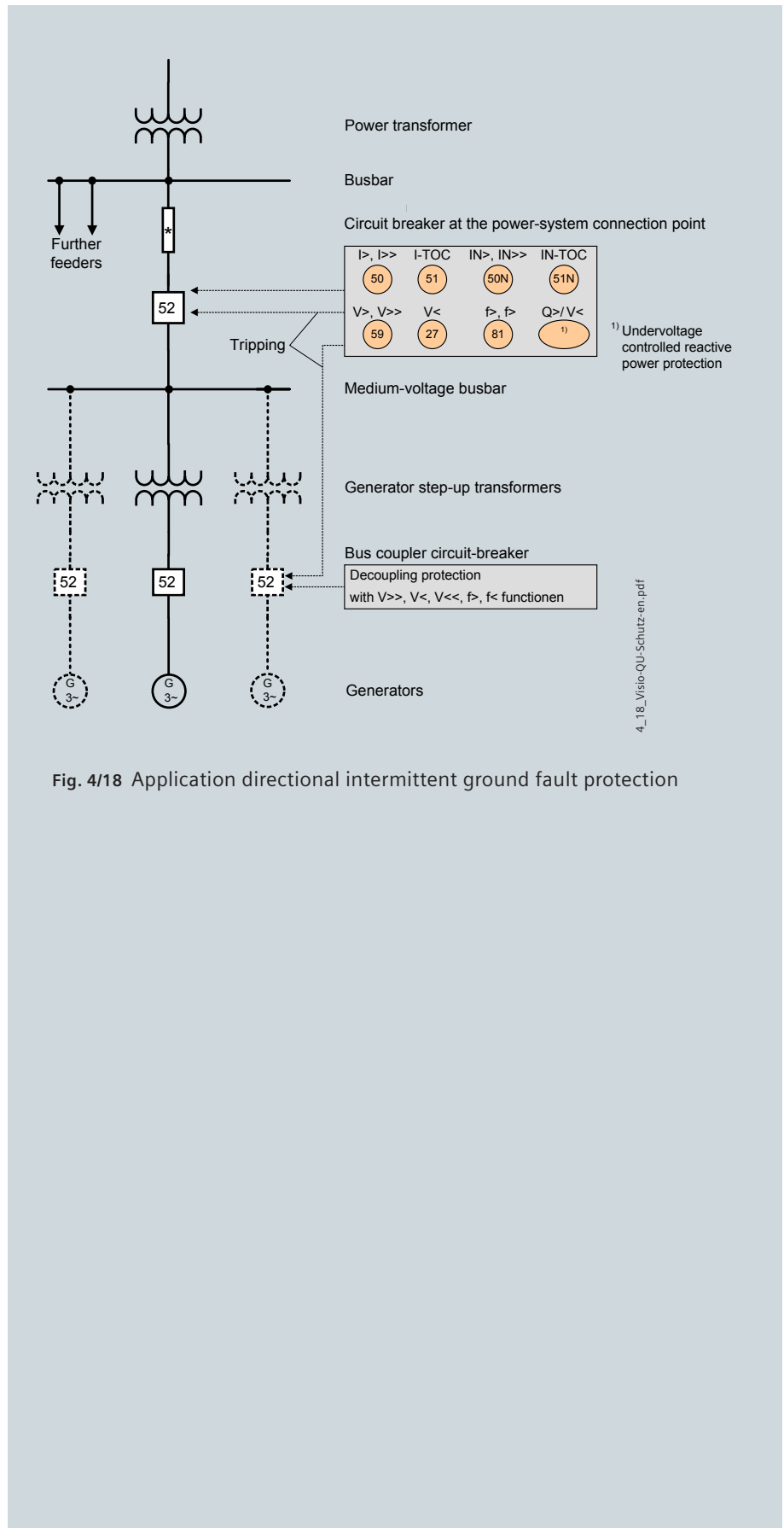


Fig. 4/18 Application directional intermittent ground fault protection

Overcurrent Protection SIPROTEC 7SJ80

Selection and ordering data

Product description	Order No.	Short code
	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19	
Overcurrent Protection SIPROTEC 7SJ80 V4.74	7SJ80 □□-□□□□□□-□□□□+□□□	
Measuring inputs, binary inputs and outputs		
Housing 1/6 19"; 4 x I, 3 BI, 5 BO (2 Changeover/Form C), 1 life contact	1	
Housing 1/6 19"; 4 x I, 7 BI, 8 BO (2 Changeover/Form C), 1 life contact	2	
Housing 1/6 19"; 4 x I, 3 x V, 3 BI, 5 BO (2 Changeover/Form C), 1 life contact	3	
Housing 1/6 19"; 4 x I, 3 x V, 7 BI, 8 BO (2 Changeover/Form C), 1 life contact	4	see next page
Housing 1/6 19"; 4 x I, 11 BI, 5 BO (2 Changeover/Form C), 1 life contact	7	
Housing 1/6 19"; 4 x I, 3 x V, 11 BI, 5 BO (2 Changeover/Form C), 1 life contact	8	
Measuring inputs, default settings		
$I_{ph} = 1 A/5 A, I_E = 1 A/5 A$	1	
$I_{ph} = 1 A / 5 A, I_{EE} \text{ (sensitive)} = 0,001 \text{ to } 1,6 A / 0,005 \text{ to } 8 A$	2	
Auxiliary voltage		
DC 24 V/48 V	1	
DC 60 V/110 V/125 V/220 V/250 V, AC 115 V, AC 230 V	5	
Construction		
Surface-mounting case, screw-type terminal	B	
Flush-mounting case, screw-type terminal	E	
Region specific default and language settings		
Region DE, IEC, language German (language changeable), standard front	A	
Region World, IEC/ANSI, language Englisch (language changeable), standard front	B	
Region US, ANSI, language US-English (language changeable), US front	C	
Region FR, IEC/ANSI, language French (language changeable), standard front	D	
Region World, IEC/ANSI, language Spanish (language changeable), standard front	E	
Region World, IEC/ANSI, language Italian (language changeable), standard front	F	
Region RUS, IEC/ANSI, language Russian (language changeable), standard front	G	
Region CHN, IEC/ANSI, language Chinese (language not changeable), Chinese front	K	
Port B (at bottom of device, rear)		
No port	0	
IEC60870-5-103 or DIGSI4/Modem, electrical RS232	1	
IEC60870-5-103 or DIGSI4/Modem, electrical RS485	2	
IEC60870-5-103 or DIGSI4/Modem, optical 820nm, ST connector	3	
PROFIBUS DP Slave, electrical RS485	9	L O A
PROFIBUS DP Slave, optical, double ring, ST connector	9	L O B
MODBUS, electrical RS485	9	L O D
MODBUS, optical 820nm, ST connector	9	L O E
DNP 3.0, electrical RS485	9	L O G
DNP 3.0, optical 820nm, ST connector	9	L O H
IEC 60870-5-103, redundant, electrical RS485, RJ45 connector	9	L O P
IEC 61850, 100Mbit Ethernet, electrical, double, RJ45 connector	9	L O R
IEC 61850, 100Mbit Ethernet, optical, double, LC connector	9	L O S
DNP3 TCP + IEC 61850, 100Mbit Ethernet, electrical, double, RJ45 connector	9	L 2 R
DNP3 TCP + IEC 61850, 100Mbit Ethernet, optical, double, LC connector	9	L 2 S
PROFINET + IEC 61850, 100Mbit Ethernet, electrical, double, RJ45 connector	9	L 3 R
PROFINET + IEC 61850, 100Mbit Ethernet, optical, double, LC connector	9	L 3 S
IEC 60870-5-104 + IEC 61850, 100Mbit Ethernet, electrical, double, RJ45 connector	9	L 4 R
IEC 60870-5-104 + IEC 61850, 100Mbit Ethernet, optical, double, LC connector	9	L 4 S
MODBUS TCP + IEC 61850, 100 Mbit Ethernet, electrical, double, RJ45 connector	9	L 5 R
MODBUS TCP + IEC 61850, 100 Mbit Ethernet, optical, double, LC connector	9	L 5 S
Port A (at bottom of device, in front)		
No port	0	
With Ethernet interface (DIGSI, I/O-Unit connection, not IEC61850), RJ45 connector	6	
Measuring/Fault recording		
With fault recording	1	
With fault recording, average values, min/max values	3	

You will find a detailed overview of the technical data (extract of the manual) under: <http://www.siemens.com/siprotec>

Overcurrent Protection SIPROTEC 7SJ80

Selection and ordering data

ANSI No.	Product description	Order No.	Short code
Overcurrent Protection SIPROTEC 7SJ80 V4.74		7SJ80 □□-□□□□□□-□□□□+□□□	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
	Basic version		F A ³⁾
50/51	Time-overcurrent protection, phase $I>$, $I>>$, $I>>>$, I_p		
50N/51N	Time overcurrent protection, ground $I_E>$, $I_E>>$, $I_E>>>$, I_{Ep}		
50N(s)/51N(s) ¹⁾	Sensitive ground fault protection $I_{EE>}$, $I_{EE>>}$, I_{EEp}		
	Intermittent ground fault protection		
87N ²⁾	High impedance REF		
49	Overload protection		
74TC	Trip circuit supervision		
50BF	Circuit-breaker failure protection		
46	Negative-sequence system overcurrent protection		
37	Undercurrent monitoring		
86	Lockout		
	Parameter changeover		
	Monitoring functions		
	Control of circuit breaker		
	Flexible protection functions (current parameters)		
	Inrush restraint		
	Basic functionality + Directional sensitive ground fault, voltage and frequency protection		F B ⁴⁾
51V	Voltage dependent inverse-time overcurrent protection		
67N	Directional time-overcurrent protection, ground, $I_E>$, $I_E>>$, $I_E>>>$, I_{Ep}		
67Ns ¹⁾	Directional sensitive ground fault protection, $I_{EE>}$, $I_{EE>>}$, I_{EEp}		
64/59N	Displacement voltage		
27/59	Under/Overvoltage		
81U/O	Under/Overfrequency, $f<$, $f>$		
47	Phase rotation		
	Flexible protection functions (current and voltage parameters): Protective function for voltage, power, power factor, rate-of-frequency change, rate-of-voltage change		
27R/32/55/59R/81R			
	Basic functionality + Directional phase & ground overcurrent, directional sensitive ground fault, voltage and frequency protection		F C ⁴⁾
51V	Voltage dependent inverse-time overcurrent protection		
67	Directional time-overcurrent protection, phase, $I>$, $I>>$, $I>>>$, I_p		
67N	Directional time-overcurrent protection, ground, $I_E>$, $I_E>>$, $I_E>>>$, I_{Ep}		
67Ns ¹⁾	Sensitive ground-fault protection, $I_{EE>}$, $I_{EE>>}$, I_{EEp}		
64/59N	Displacement voltage		
27/59	Under/Overvoltage		
81U/O	Under/Overfrequency, $f<$, $f>$		
47	Phase rotation		
	Flexible protection functions (current and voltage parameters): Protective function for voltage, power, power factor, rate-of-frequency change, rate-of-voltage change		
27R/32/55/59R/81R			
	Basic functionality + Directional phase & ground overcurrent, directional sensitive ground fault, voltage and frequency protection + Undervoltage controlled reactive power protection + Directional intermittent ground fault protection		F F ⁴⁾
51V	Voltage dependent inverse-time overcurrent protection		
67	Directional overcurrent protection, phase, $I>$, $I>>$, $I>>>$, I_p		
67N	Directional overcurrent protection, ground, $I_E>$, $I_E>>$, $I_E>>>$, I_{Ep}		
67Ns ¹⁾	Directional sensitive ground fault protection, $I_{EE>}$, $I_{EE>>}$, I_{EEp}		
67Ns ²⁾	Directional intermittent ground fault protection		
64/59N	Displacement voltage		
27/59	Under/Overvoltage		
81U/O	Under/Overfrequency, $f<$, $f>$		
	Undervoltage controlled reactive power protection, $Q>/V<$		
47	Phase rotation		
	Flexible protection functions (current and voltage parameters): Protective function for voltage, power, power factor, rate-of-frequency change, rate-of-voltage change		
27R/32/55/59R/81R			
			see next page

4

1) Depending on the ground current input the function will be either sensitive (I_{EE}) or non-sensitive (I_E)

2) Function only available with sensitive ground current input (Position 7=2)

3) Only if position 6 = 1, 2 or 7

4) Only if position 6 = 3, 4 or 8

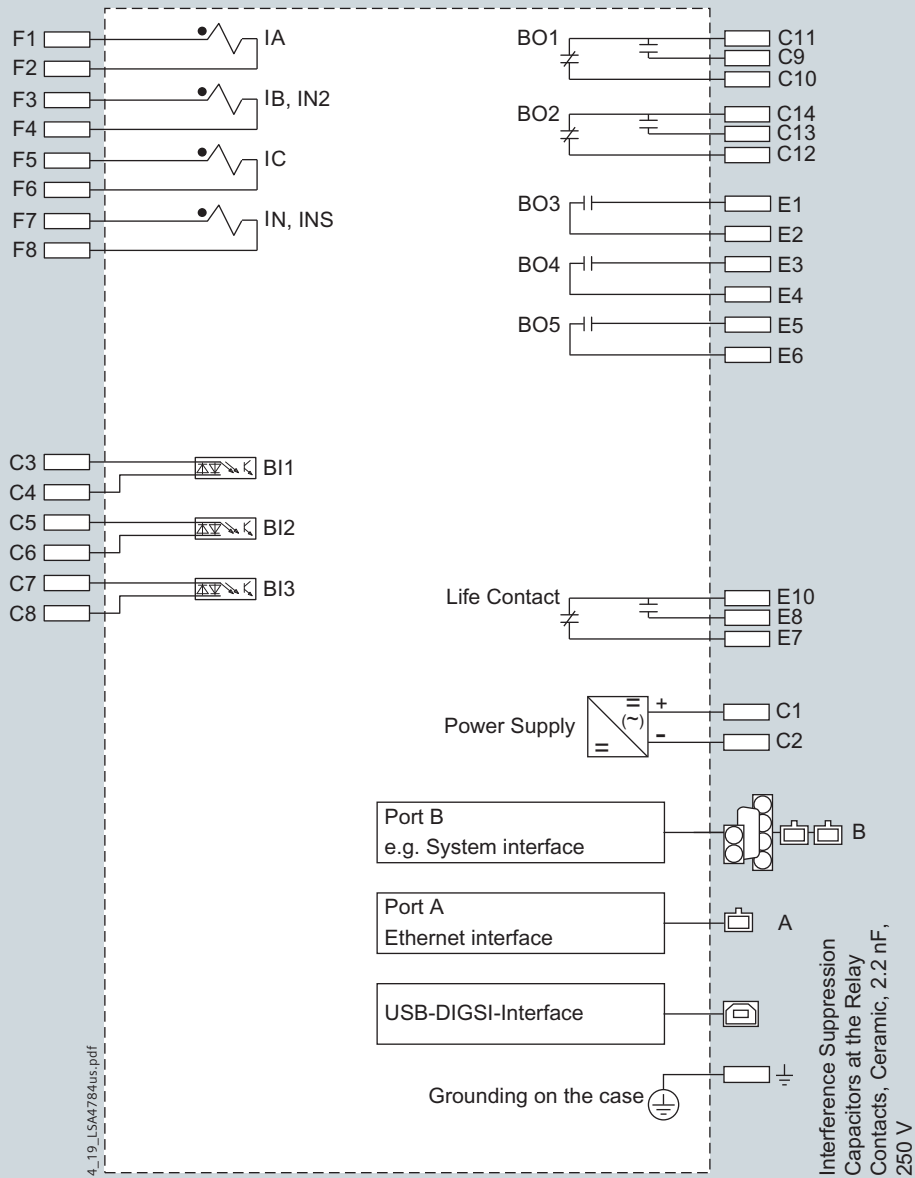
Overcurrent Protection SIPROTEC 7SJ80

Selection and ordering data

ANSI No.	Product description	Order No.	Short code
	Overcurrent Protection SIPROTEC 7SJ80 V4.74	7SJ80 □□-□□□□□□-□□□□□+□□□□	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
	Basic functionality + Directional phase overcurrent, voltage and frequency protection + synchrocheck		F Q ⁵⁾
51V	Voltage dependent inverse-time overcurrent protection		
67	Directional time-overcurrent protection, phase, $I>$, $I>>$, $I>>>$, I_p		
27/59	Under/Overtension (phase-to-phase)		
81U/O	Under/Overfrequency, $f<$, $f>$		
47	Phase rotation		
25	Synchrocheck		
27R/59R/81R	Flexible protection functions (current and voltage parameters): Protective function for voltage, rate-of-frequency change, rate-of-voltage change		
	Automatic Reclosing (AR), Fault Locator (FL)		
	Without		0
79	With automatic reclosure function		1
FL	With FL (only with position 6 = 3, 4 or 8)		2
79/FL	With automatic reclosure function and FL (only with position 6 = 3, 4 or 8)		3
	Conformal Coating		
	for 7SJ801, 7SJ803		Z Y 1 5
	for 7SJ802, 7SJ804, 7SJ807, 7SJ808		Z Y 1 6

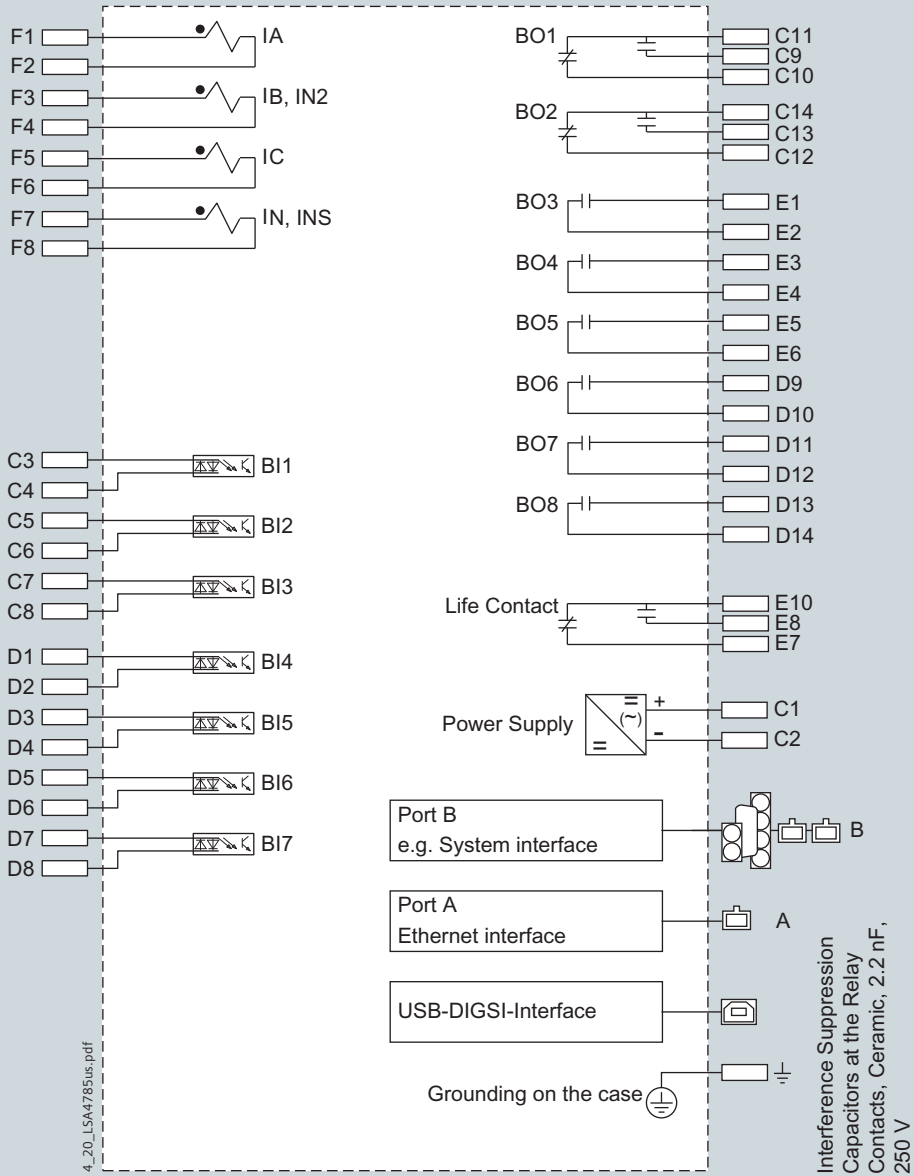
5) Only with position 6 = 3 or 4 and position 16 = 0 or 1

You will find a detailed overview of the technical data (extract of the manual) under: <http://www.siemens.com/siprotec>



Overcurrent Protection SIPROTEC 7SJ80

Connection diagrams



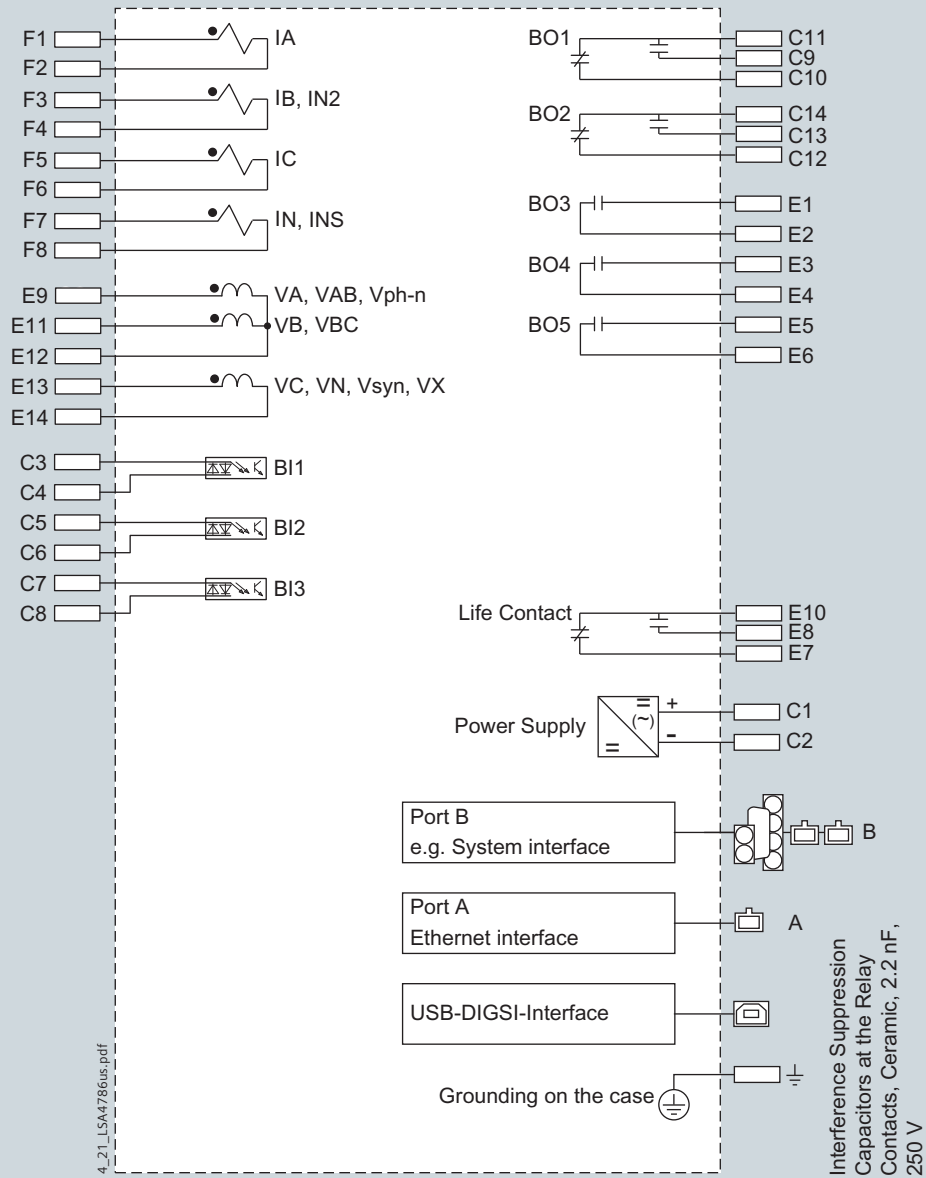
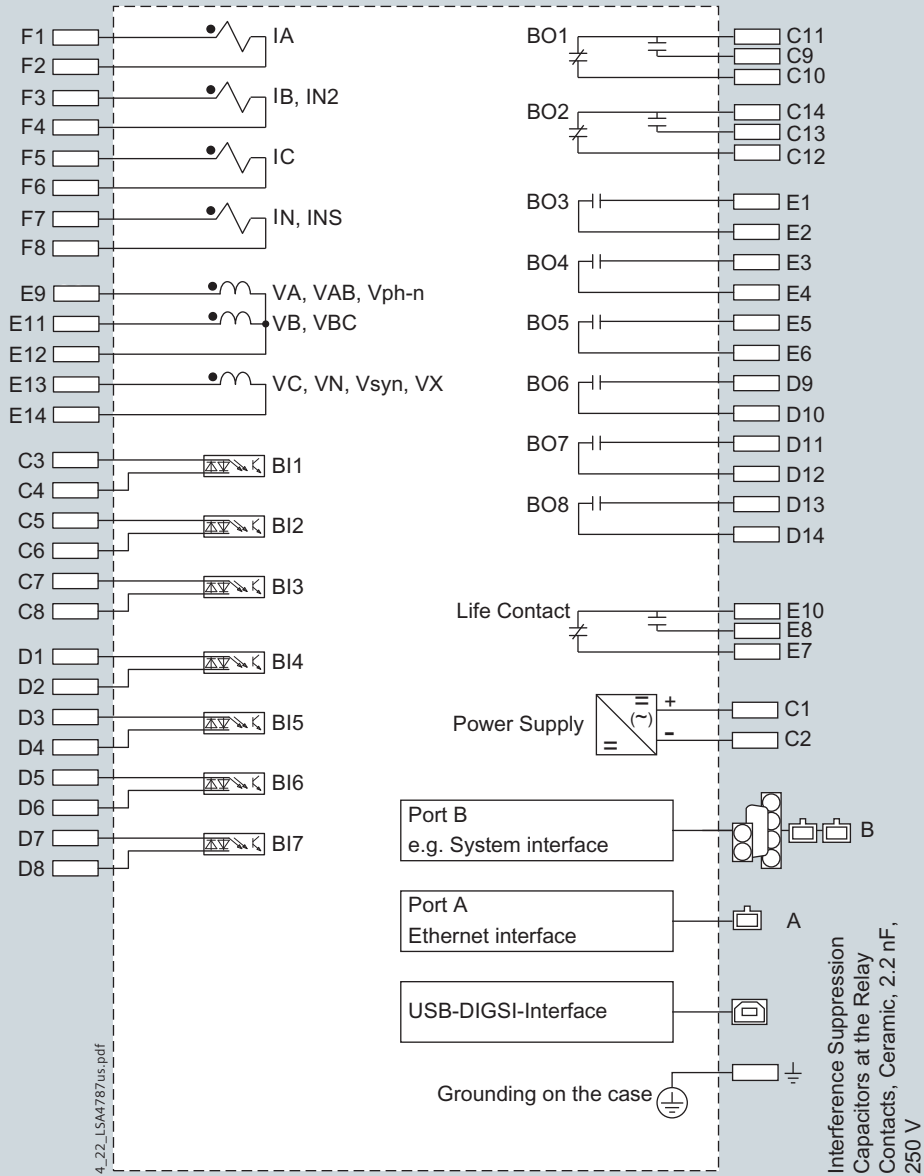


Fig. 4/21 Multifunction protection SIPROTEC 7SJ803

Overcurrent Protection SIPROTEC 7SJ80

Connection diagrams



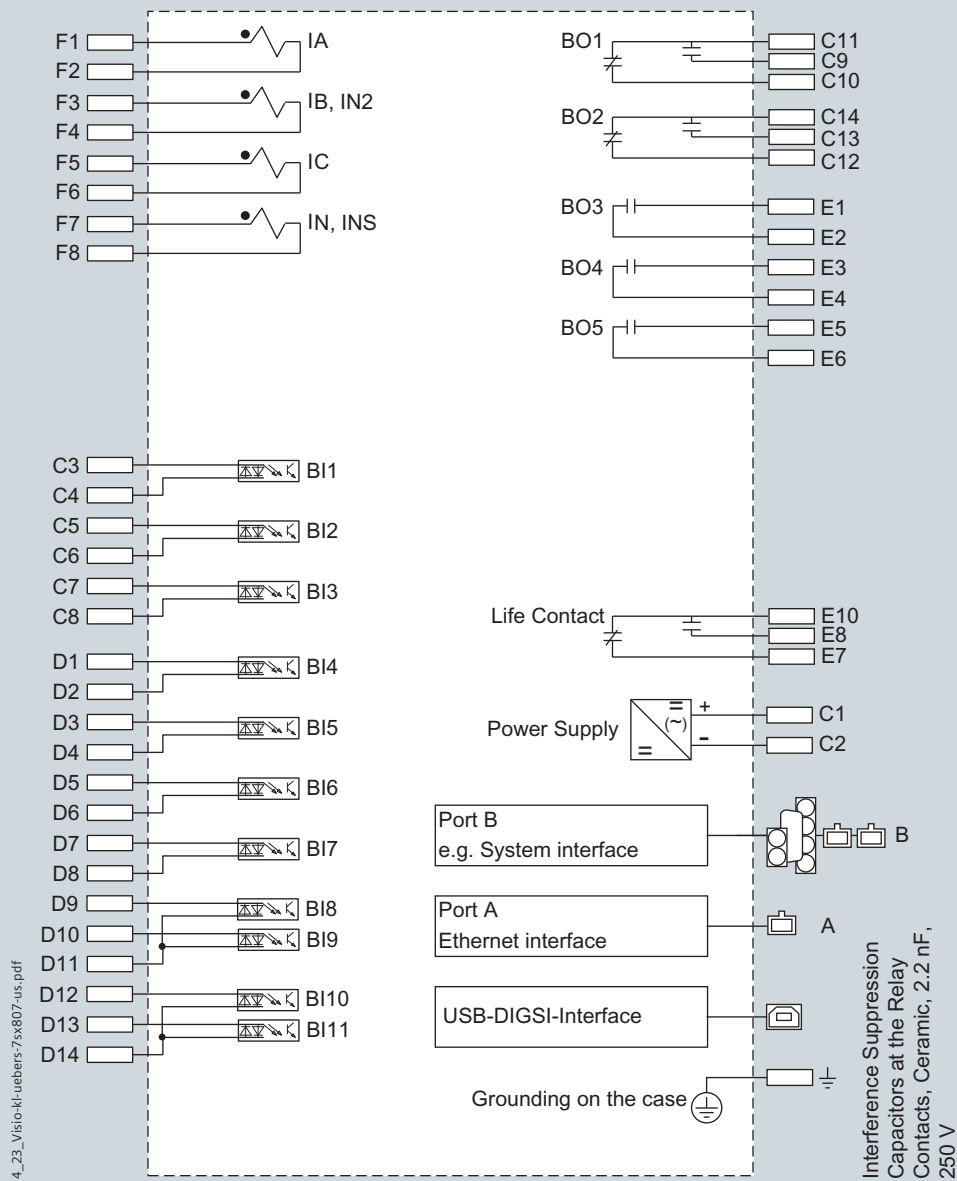
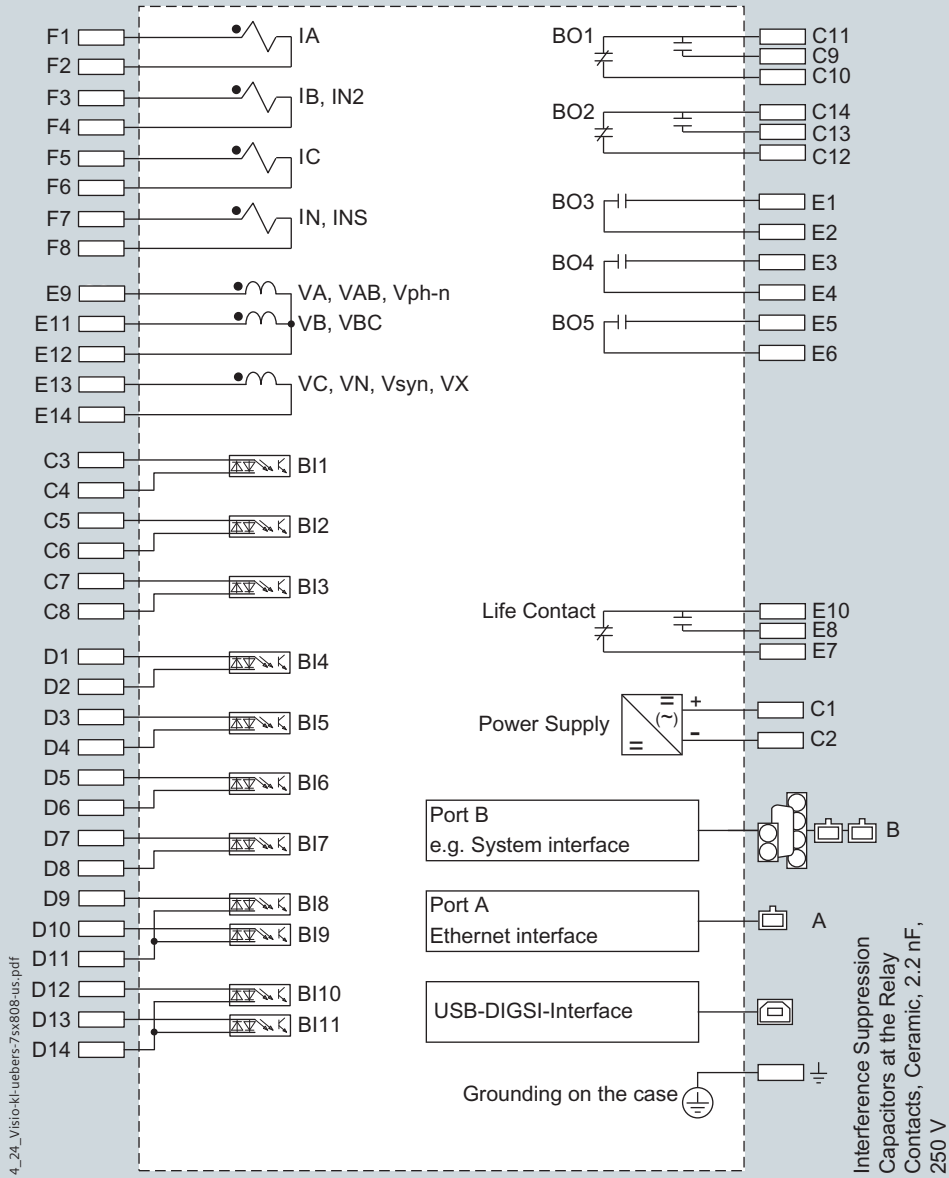


Fig. 4/23 Multifunction protection SIPROTEC 7SJ807

Overcurrent Protection SIPROTEC 7SJ80

Connection diagrams

4



Connection of current and voltage transformers

Standard connection

For grounded networks, the ground current is obtained from the phase currents by the residual current circuit.

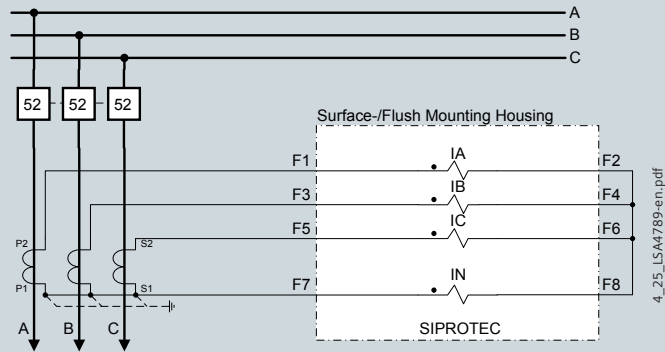


Fig. 4/25 Residual current circuit without directional element

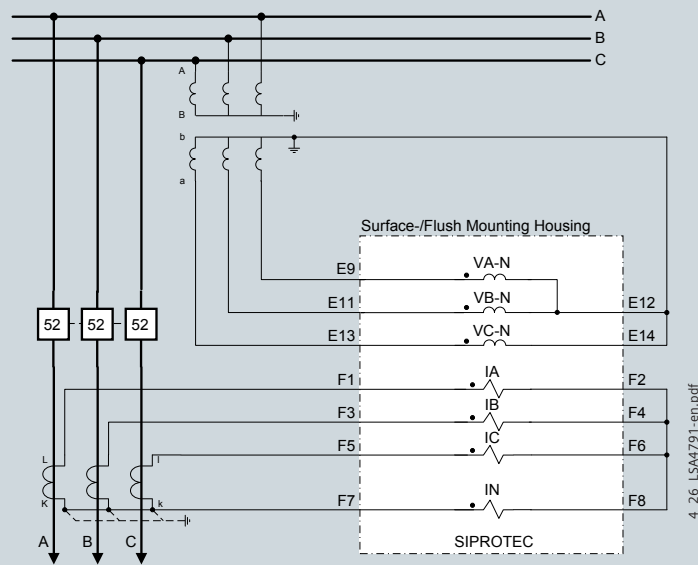


Fig. 4/26 Residual current circuit with directional element

For power systems with small earth currents, e.g. isolated or compensated systems, the earth current is measured by a zero-sequence current transformer.

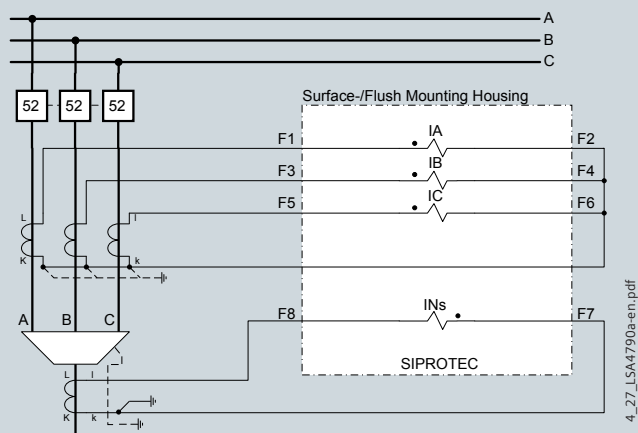


Fig. 4/27 Sensitive ground current detection without directional element

Overcurrent Protection SIPROTEC 7SJ80

Connection examples

Connection for compensated networks

The figure shows the connection of two phase-to-ground voltages and the V_E voltage of the broken delta winding and a phase-balance neutral current transformer for the ground current. This connection maintains maximum precision for directional ground-fault detection and must be used in compensated networks.

4

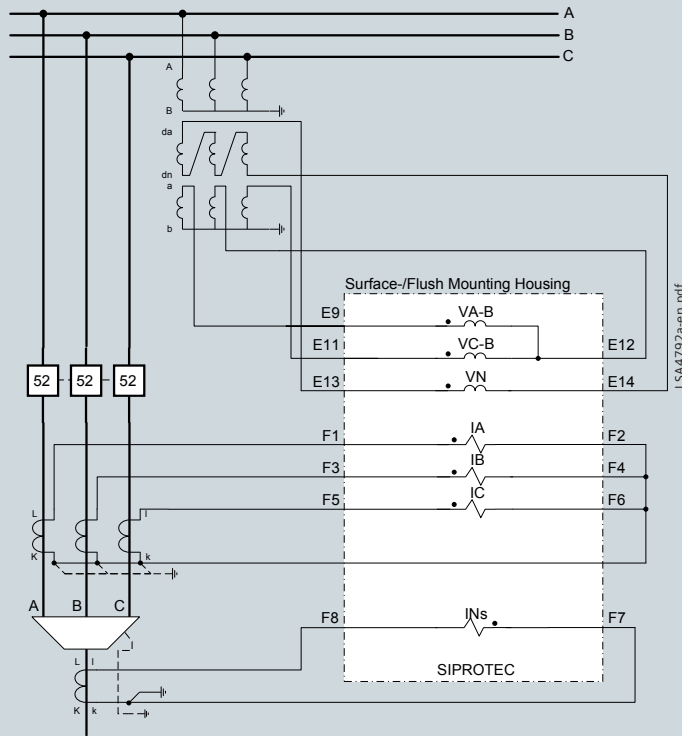


Fig. 4/28 Sensitive directional ground-fault detection with directional element for phases

Sensitive directional ground-fault detection.

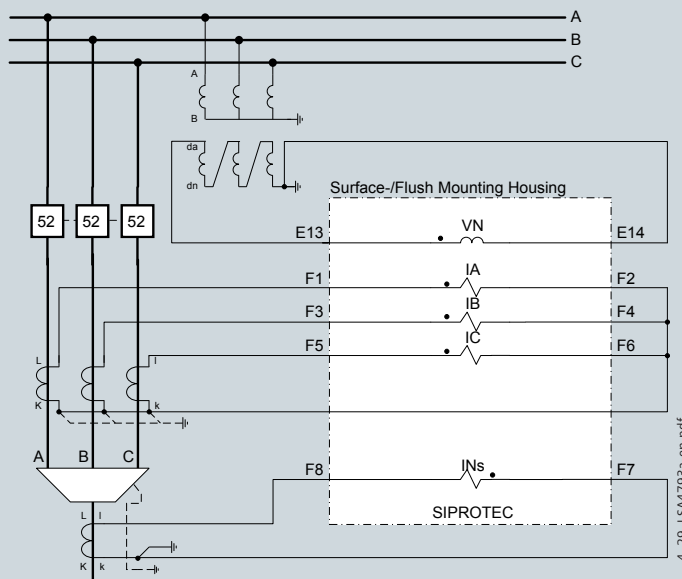


Fig. 4/29 Sensitive directional ground-fault detection

Connection for the synchrocheck function

If no directional earth-fault protection is used, connection can be done with just two phase current transformers. For the directional phase short-circuit protection, the phase-to-phase voltages acquired with two primary transformers are sufficient.

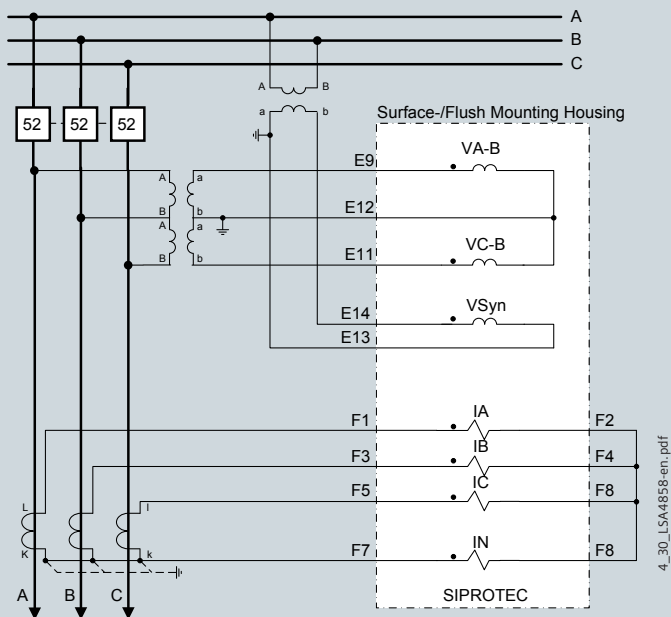


Fig. 4/30 Measuring of the busbar voltage and the outgoing feeder voltage for synchronization

Overcurrent Protection SIPROTEC 7SJ80

Connection types

Overview of connection types

Type of network	Function	Current connection	Voltage connection
(Low-resistance) grounded networks	Time-overcurrent protection phase/ground non-directional	Residual circuit, with 3 phase-current transformers required, phase-balance neutral current transformers possible	–
(Low-resistance) grounded networks	Sensitive ground-fault protection	Phase-balance neutral current transformers required	–
Isolated or compensated networks	Overcurrent protection phases non-directional	Residual circuit, with 3 or 2 phase-current transformers possible	–
(Low-resistance) grounded networks	Directional time-overcurrent protection, phase	Residual circuit, with 3 phase-current transformers possible	Phase-to-ground connection or phase-to-phase connection
Isolated or compensated networks	Directional time-overcurrent protection, phase	Residual circuit, with 3 or 2 phase-current transformers possible	Phase-to-ground connection or phase-to-phase connection
(Low-resistance) grounded networks	Directional time-overcurrent protection, ground-faults	Residual circuit, with 3 phase-current transformers required, phase-balance neutral current transformers possible	Phase-to-ground connection required
Isolated networks	Sensitive ground-fault protection	Residual circuit, if ground current $> 0.05 I_N$ on secondary side, otherwise phase-balance neutral current transformers required	3 times phase-to-ground connection or phase-to-ground connection with broken delta winding
Compensated networks	Sensitive ground-fault protection $\cos \varphi$ measurement	Phase-balance neutral current transformers required	3 times phase-to-ground connection or phase-to-ground connection with broken delta winding

Table 4/4 Overview of connection types